

that these sounds are closely connected with ordinary earthquake-sounds, and Prof. Hobbs finds that the Calabrian villages from which brontidi are reported are also those which have suffered most from disastrous earthquakes, and that they are ranged along the more prominent seismotectonic lines of the district.

In great detail Prof. Hobbs studies, not only the places damaged by the important earthquakes of 1638, 1659, 1783, 1894, and 1905, but also those at which numerous slight shocks were observed, for the latter, owing to their small disturbed areas, seem to be the most useful indices of the course of seismotectonic lines. The positions of more than 300 such lines in Calabria and north-eastern Sicily are estimated and drawn upon a series of maps, as well as the bearings of joint-planes, the trend of the volcanotectonic lines, and the distribution of brontidi.

It will be seen from this brief abstract that Prof. Hobbs's memoirs possess considerable interest. They are the result of extensive reading, and contain many useful references. But his wide generalisations seem to me to be based on insecure principles and insufficient data. Iso-seismal lines, it is well known, are elongated in the direction of the originating faults, but the positions of a few places at which shocks are felt cannot determine a line of fracture. For instance, one of the British seismotectonic lines is located by the positions of four places, two of which are more than 200 miles apart. The seismotectonic lines revealed by the New England earthquake of 1870 are based on the positions of about a score of places distributed over an area reaching from Quebec to New-haven, and on about a dozen apparent directions of the shock. When observed in houses, such directions are almost invariably perpendicular to the principal walls, but Prof. Hobbs assumes that they indicate that the shocks were transmitted along parallel seismotectonic lines. In Calabria, on the other hand, the damaged villages are so numerous that it would be strange if many of them were not collinear. Several of the seismotectonic lines plotted by Prof. Hobbs no doubt correspond with lines of fracture, but the existence of a very large number of his lines must, I think, be regarded as doubtful. Industrious as he has been in the collection of materials, he has tried within little more than a year to achieve results which the long-continued labours of many men might fail to establish.

C. DAVISON.

HYDRATES IN AQUEOUS SOLUTION.

A RECORD of researches which have been carried out by Prof. H. C. Jones with his students and confrères has recently been published by the Carnegie Institution.¹ The investigations which have been undertaken were to elucidate an observation made by Jones and Ota when studying the freezing points of solutions of double salts in order to ascertain whether in solution they remained as constituent molecules or were broken down. They found that concentrated solutions gave abnormally low freezing points, the molecular lowering of freezing point passing through a well-defined minimum as the concentration changed. Now according to the ionic theory as then expressed, the molecular lowering should decrease continuously as the concentration of the solution increased.

A very large number of solutions of salts, acids, and bases, and neutral organic substances have now been studied, and as a result it has been found that this excessive depression as the concentration increases is a general property of solutions. In order to explain this digression from the generally accepted rendering of the ionic theory, Jones postulates that "in solution a part of the solvent is combined with the dissolved substance and no longer plays the rôle of solvent, at least so far as the freezing point method is concerned."

By a determination of the freezing point, conductivity, and specific gravity of the solutions, it has been found possible to calculate approximately the total amount of water held in combination by the dissolved substance, and consequently the approximate amount combined with one molecule of the compound or of the ions resulting from it.

¹ "Hydrates in Aqueous Solution." By Harry C. Jones. Pp. viii+264. (Washington: Carnegie Institution, 1907.)

The theory proposed here differs from that suggested by Mendeléeff, who considered that such substances as sulphuric acid and calcium chloride form a few definite compounds with the water in which they are dissolved. But the present theory supposes that combination between the dissolved substance and water to be a general phenomenon. The compound forms, say, for example, calcium chloride, a complete series of hydrates extending from a few molecules of water to at least thirty, all the intermediate stages being represented.

The memoir commences with an introduction, in which the earlier work is reviewed and the freezing-point and conductivity apparatus used by the author are described. Then follows part i., dealing with the evidence for the existence of hydrates in aqueous solution and the approximate composition of the hydrates formed by a large number of electrolytes. The work here described was carried out by Getman and Bassett. Attention is directed to the effect of temperature on water of crystallisation, as bearing on the theory of hydrates in solution. It is shown that salts which on crystallisation contain water of crystallisation are able to combine when in solution at ordinary temperatures with a much larger quantity of water than they are able to bring with them out of solution on crystallisation. The results obtained are illustrated in many cases graphically by curves and in other cases by tables.

Part ii. is chiefly the work of Uhler, and deals with spectroscopic investigations. The spectrographic photographs which are given have been magnificently reproduced, and form quite a feature of the book. The colour changes produced, for example, by the addition of different salts to cobalt salts have been investigated quantitatively. That is to say, the absorption spectra of the substances, separately and when mixed in known quantities, have been observed with a direct-reading spectroscope, and thus the wave-lengths and absorption bands obtained. The special spectrograph which has been used to obtain the photographic record of the absorption bands is also described. The final section deals with non-aqueous solutions, the solution of substances in methyl and ethyl alcohol having been studied. The results seem to indicate that some substances at least, such as lithium chloride, bromide, and nitrate, combine to some extent with the solvent. However, this portion of the work is yet in its initial stage, and much yet remains to be done. We understand that the author is extending the work in this direction.

Altogether, the memoir is an extremely valuable contribution to the study of the subject, more especially in connection with concentrated solutions. It has often been urged, and with a considerable amount of truth, that the ionic theory is simply a specialised hypothesis, which is true only of dilute solutions. Prof. Jones has gone far to remove this reproach by broadening the basis of the theory and enlarging its scope. The publishers, the Carnegie Institution, must also be congratulated upon the splendid way in which the letterpress and diagrams have been got up.

F. M. P.

PRODUCTION AND DECAY OF MEDIAEVAL STAINED GLASS.¹

THE earliest direct evidence as to the methods of mediaeval glass-painting is contained in the treatise of Theophilus ("Diversarum Artium Schedula"), which dates back in all probability to the latter half of the twelfth century; here one finds detailed instructions for the making of the glass as well as for its formation into the flat sheets or "tables" in which it is required by the glass-painter.

This treatise makes it clear that at that time such window glass was for the most part made by what is generally known as the "muff" process. The process referred to is one of the three known methods of making window glass, namely:—

- (1) Cast or plate glass, made by pouring molten glass on to a flat stone or metal slab.
- (2) Muff or cylinder glass, in which the glass is worked

¹ Abstract of a paper read before the Society of Arts on March 13 by Mr. Noel Horton.

into the form of a hollow cylinder by means of the blow-pipe, which cylinder is subsequently opened out into a flat sheet.

(3) Spun or crown glass, in which a bulb-shaped mass of blown glass is converted into a disc by rotating it rapidly whilst in a plastic state.

The earliest known window glass, that of the Romans, was produced by the first of these methods; in fact, it has hitherto been supposed that the Romans knew no other way of making glass into sheets. A careful examination of the glass brought to light by the excavations at Silchester, however, leaves no room for doubt that the Romans were acquainted with the art of making blown window glass according to the "muff" process.

There are reasons for thinking that the making of window glass was not handed down from the Romans, but was re-discovered in the Middle Ages, and the author thinks it most probable (although evidence is too scanty to justify this as a statement of fact) that the glass of the earliest stained-glass windows, that is, those of the ninth and tenth centuries, was made in the same way as the cast window glass most generally employed by the Romans, this being the method that would most naturally suggest itself in the first place.

The composition of the glass described by Theophilus was quite different from that of the Romans, being produced, according to the treatise referred to, by heating a mixture of sand and the ashes of beechwood. It is probable, however, that the glass varied very considerably in composition at different times and in different places, owing to the impurity of the sand used and the varying nature of the wood ashes, which would in all probability be obtained by burning whatever species of timber came nearest to hand.

Considering these facts, mediæval glass would be expected to reveal on analysis a fairly complicated composition, and, whilst varying considerably, to show in general a richness in alkali (usually potash) and poorness in lime.

In order to obtain further information on this point, the author, in conjunction with Mr. Percy Williams, determined accurately the composition of some typical specimens of mediæval stained glass, of which a description is given in the paper. The following table is a summary of the results obtained:—

Composition of Mediæval Glass.

Material	Sandiacre	Dale Abbey	Modern window glass
Silica	54.01	46.94	70
Phosphoric acid ...	4.18	4.11	—
Potash	13.20	16.96	15
Soda	1.70	0.12	—
Lime	17.37	19.01	13
Magnesia	5.33	5.00	—
Alumina	2.41	3.02	—
Iron	0.81	1.46	2
Manganese	1.03	1.37	—
Moisture due to decay ...	0.21	2.16	—

These results are of interest in several directions, chiefly, however, as revealing the presence of a considerable amount of phosphorus in the glass. The evidence this affords as to the making of the glass, and its effect on the nature of the glass, are discussed in the paper, and attention is directed to the disturbing influence this unlooked-for ingredient has on the process of analysis.

The importance of this point lies in the fact that if a partial analysis of the glass is made—with the view of determining the amount of alumina, for example—or if an analysis is attempted without the possibility of the presence of phosphorus being recognised, the results are liable to be seriously inaccurate. A summary of the method adopted by Mr. Williams for obtaining the analyses quoted follows, this being based on the removal of the phosphorus by silver carbonate.

The paper then passes on to discuss the phenomena of the decay of old stained glass in the light of the peculiar composition revealed by these analyses.

Mediæval glass decays in a very characteristic manner. Very commonly the glass becomes covered with little pits, for all the world like the worm-holes one often sees in an old oak cabinet.

The process of decay in glass is undoubtedly a parallel on a small scale to the change produced on a large scale by the action of time and weather on geological formations, such as chalk and sandstone—a combination of corrosion and internal change.

Corrosion of the surface of glass is produced by the long-continued action of moisture, which gradually extracts the

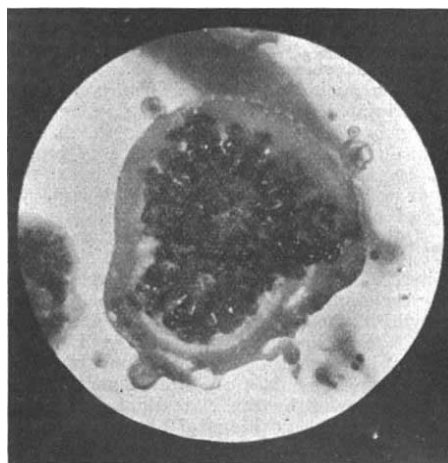


FIG. 1.—Photomicrograph of an area of decomposition in mediæval glass.

soluble silicates, leaving the insoluble silica in a thin film, the glass thereby becoming iridescent. Owing to the large proportion of lime it contains, however, mediæval glass does not become iridescent as the result of corrosion. On the extraction of the alkali by water this lime is left behind with the silica, and forms with it a hard, insoluble silicate of lime, which adheres to the corroded surface of the glass, forming an opaque scum or patina. In some cases this is so marked that the glass appears to be covered with a coat of cement.

The peculiar pitting of old stained glass is not, however,

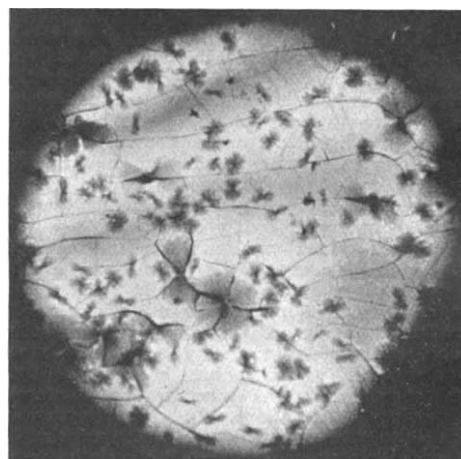


FIG. 2.—Photomicrograph of similar structures produced experimentally in modern window glass.

in the author's opinion, due to corrosion at all, but to a change in the constitution of the glass. As is well known, glass changes its constitution and becomes crystalline if kept at a red heat for a length of time. What happens in a few hours when the glass is hot tends to take place on prolonged exposure to the atmosphere, with this difference, that when the glass is molten its molecules can

freely move about, whereas when it is cold and rigid such freedom of movement is impossible; in consequence the definite formation of crystals cannot take place, and the result of the change is different. What happens is this. In the first place, molecules of the same kind tend to separate out from the homogeneous mixture and collect round a point, forming a centre of decomposition. Proceeding from this centre the glass is found decomposing into definite compounds in an ever-enlarging circle until it reaches a point at which the strain set up in the glass by this molecular movement results in a crack forming round the area of decomposition, and then the whole mass comes away, leaving behind it a little hole or pit in the surface of the glass.

Such are the two forces at work on the decay of glass—corrosion without and decomposition within—and, of course, they act simultaneously. As the pits are formed they are extended by corrosion, forming a resting place, in fact, for the water, until eventually the whole fabric of the glass is destroyed.

According to varying circumstances—the position of the window as affecting its degree of exposure, the climate in which it is placed, differences in composition and mechanical state of the glass—we get all sorts of variations in the precise effect of decay in particular instances.

It is a well recognised fact that glass containing a large proportion of earths, that is, lime, magnesia, and alumina, is especially liable to become crystalline. If, then, one is correct in thinking that the peculiar pitting of Gothic glass is due to a similar change of constitution, one would expect to find it excessively rich in these constituents, and we have already seen that this is, in fact, the case.

On the other hand, glass containing excess of alkali has an equally recognised tendency to go “blind,” that is, to become covered with a film, due to corrosion. Finally, glass with a high content of silica, with earth and alkali equally balanced, may be looked upon as highly resistant in both directions. It is such glasses which decay slowly and with little tendency to devitrification, the surface being merely etched by corrosion, leaving the large proportion of silica in a coherent thin film, producing gorgeous effects of iridescence.

Besides the glass itself, a study of the materials used for producing the enamel with which the glass was painted to represent figures and subjects is a matter of some importance, which is fully discussed in the paper. After going thoroughly into the evidence afforded by those mediæval pay-rolls which have been preserved, dealing with the execution of stained-glass windows, the author comes to the conclusion that the enamel in question was prepared by making a fusible opaque black glass, technically known as “geet,” probably because it resembled jet in appearance (the word jet being in writings of the period variously spelt jeat, ieat, geat, geet); this material would be used as a flux, and mixed with the oxides of iron and copper to make the paint. Experiment shows that an enamel prepared in this way is in every respect similar to that used in the finest examples of mediæval stained glass.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

AN exhibition illustrating a course of lectures on Japanese education given under the auspices of the University of London by Baron Kikuchi, will be opened on Tuesday next at the Victoria and Albert Museum (Indian Section), South Kensington. The exhibition will remain open until the end of June.

RECENT statistics published by the French Minister of Public Instruction give the number of students attending courses of instruction in French universities and higher educational institutions. The total reaches 38,197, of whom 3434 are foreigners—a number much larger than usual owing to the temporary closing of certain Russian universities. Of the native students, 1364 are women. The number of students at some of the larger universities are as follows:—Paris, 15,789; Lyons, 2783; Toulouse, 2675; Bordeaux, 2496; Nancy, 1841; Montpellier, 1752; Lille, 1560; Rennes, 1498; and Aix-Marseilles, 1269. The

Paris students are distributed among the different faculties and schools as follows:—law, 7032; medicine, 3369; letters, 2413; science, 2022; and pharmacy, 953. The total number of French university men students include in the various departments of learning:—law, 15,427; medicine, 7501; letters, 4605; science, 5881; and pharmacy, 2224.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, November 15, 1906. —“On the Effect of High Temperatures on Radium Emanation and its Products.” By Walter **Makower** and Sidney **Russ**. Communicated by Prof. A. Schuster, F.R.S.

In a previous paper it was shown that the activity of radium emanation sealed in a quartz tube is temporarily changed by subjecting it for a short time to temperatures between 1000° C. and 1200° C. From the results obtained it seemed probable that this change was not due to any alteration of the emanation itself, but rather to a change of activity of one of the more quickly decaying products of the emanation with which it is in equilibrium. To settle this point measurements were made of the rate of decay of the emanation when kept at 1100° C. Subsequently experiments were made on the effect of high temperatures on the active deposit collected on a platinum wire by exposure to the emanation.

The results obtained were:—

(1) The change in activity noticed when radium emanation is subjected to a high temperature is not due to any alteration in the emanation itself, since its time period is unaltered when it is maintained at a temperature of 1100° C.

(2) The change is due *either* to a change in radium B or C, since the activity of a mixture of these two substances can be changed by heating.

(3) The change is *probably* due to some influence of temperature on radium C. This conclusion is in agreement with the statement made by Curie and Danne.

In a note the authors discuss some recent observations made by Dr. Bronson which appear at first sight difficult to reconcile with the above conclusions. As a result of his experiments, Dr. Bronson concludes that there is no change of activity in radium even when exposed to temperatures of 1600° C.

It is, however, pointed out by the authors that there are several important differences between Dr. Bronson's experiments and their own, the most important of which is that Dr. Bronson measured the activity of the radium while hot, whereas they always allowed the active deposit to cool before making measurements. It is on this account that the authors consider that the results of Dr. Bronson and their own are not necessarily contradictory.

Zoological Society, April 9.—Dr. Henry Woodward, F.R.S., vice-president, in the chair.—A collection of fishes made in the eastern watershed of the Transvaal by Captain G. E. Bruce, and presented to the British Museum: G. A. **Boulenger**. The collection contained specimens of eighteen species, of which several had not been previously recorded from the Transvaal, and five were new.—The osteology of the oligomyodian and diacromyodian Passeres: W. P. **Pycraft**. After referring to his previous contribution (published in the Proceedings) on the osteology of the eurylæmid and tracheophone Passeres, the author remarked that there seemed little room for doubt but that the diacromyodian and oligomyodian Passeres must be regarded as divergent branches of a common stem. The latter sub-order included the Tyranniformes, Phytotomidae, and Pittidae, while the former embraced the remaining Passeres. In the present communication some fourteen families were described, and these were divided into four groups, Hirundines, Muscipapæ, Laninæ, and Gymnorhinæ. This arrangement was based, not on osteological characters alone, but also on the evidence of pterylosis and certain wing-muscles. The author proposed to include the Vireonidae with the Muscipapæ, and the Vireolanidae with the Gymnorhinæ. With this last group he proposed, tentatively at any rate, to include the Paradiseidae,